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## Paleomagnetic Study of the Miocene Continental Deposits in La Venta Badlands, Colombia

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### INTRODUCTION

The Honda Group, distributed along the Magdalena River between the Central and Eastern Cordillera of Colombian Andes (Fig. 1), is famous for occurrence of Tertiary fossil mammals, the La Venta fauna. Takemura (1983) made a detailed geologic survey of the Honda Group and overlying Gigante Formation around Villa Vieja, Huila Department, where the classical works on the La Venta fauna were carried out (Stirton, 1951; Fields, 1959). The present paper describes preliminary results of a paleomagnetic study which was performed with the aid of stratigraphic data of Takemura (1983).

### GEOLOGICAL SETTING

The Tertiary strata exposed in La Venta Badlands and its adjacent area are the Honda Group and Mesa Group. The Honda Group, widely distributed in the north of Villa Vieja, is about 700 m thick. It is divided into three parts (Fields, 1959); the lower and middle members are referred as El Libano Sands and Clays and Cerbatana Gravels and Clays, respectively. The upper part is mainly composed of sands and clays, including highly fossiliferous layers, such as the Monkey Unit and Fish Bed. The Honda Group is unconformably covered by the Mesa Conglomerate of the Mesa Group. The Mesa Group contains a large amount of volcanic sands and pumice layers, the Gigante Formation, which represent the major explosive volcanic activity in the early stage of the Andean orogeny (Van Houten, 1976).

The La Venta fauna is assigned to the Friasian stage of the South American land mammal age (Hirschfeld and Marshall, 1976). The Friasian stage is defined by a few local faunas found from the Collón Curá Formation in south Argentina. Marshall et al. (1977) reported K-Ar ages ranging from 15.4 to 14.0 Ma from volcanic rocks in the Collón Curá Formation. No chronological evidence, however, has been obtained directly from the Honda Group. Therefore, age of the La Venta fauna is still uncertain.

Takemura and Danhara (1983) obtained a fission track age of zircons,  $7.8 \pm 0.5$  Ma, from the Gigante Formation exposed between Neiva and Villa Vieja. This date is concordant with a K-Ar age of biotite from the same formation,  $8.5 \pm 0.4$  Ma, reported by Van Houten (1976). Thus, the Gigante Formation gives a younger limit of about 8 Ma for the age of the Honda Group.

### SAMPLING

Samples for magnetic measurements were collected from 14 sites at La Venta, and from

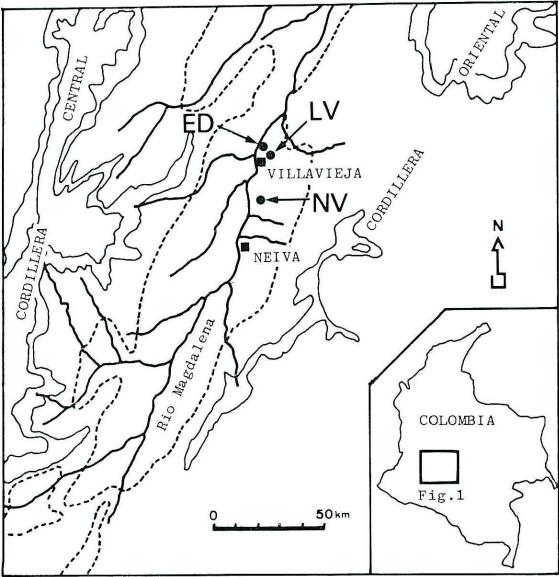


Fig. 1 Map showing location of the sampling site around La Venta Badlands. LV: La Venta. ED: El Dinde, NV: site between Neiva and Villa Vieja. Distribution of Cenozoic deposits in the Magdalena valley is outlined by dashed lines, and Cordillera Central and Cordilera Oriental by 2500 m and 3000 m contours. Base map from Van Houten (1976).

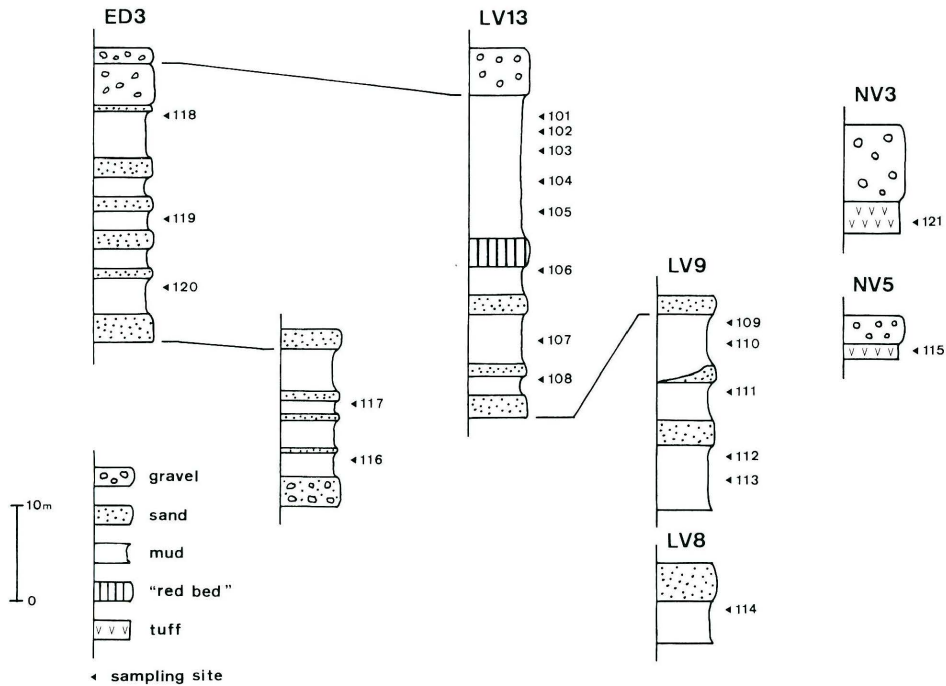


Fig. 2 Columnar sections of sampling localities and horizon of paleomagnetic samples.





ponent, which was probably acquired as viscous remanent magnetization (VRM). In response to further AF treatments, magnetic vectors decayed linearly toward the origin. Intensity of the magnetization decreased about 10 to 25% of the initial value after the demagnetization at 600 Oe. The magnetic component observed after the AF demagnetization at 100 Oe dominates the NRM, and can be assumed the original magnetization which represents direction of the geomagnetic field at the time of or shortly after the deposition.

Other samples were routinely demagnetized in peak AF of 100 Oe to remove the VRM component. Then magnetization of all samples were measured, and site mean directions were calculated.

## RESULTS AND DISCUSSION

The site mean directions and precision parameters are listed in Table 1. Some sites where the number of samples were less than 2 or where magnetic directions showed no significant clustering were omitted from the table. The mean directions and positions of virtual geomagnetic poles (VGP's) are plotted on equal-area projections in Fig. 4. Latitudes of the VGP are shown along a composite columnar section in Fig. 5, to show magnetic polarity zonation.

As shown in these figures, most of the sites show normal magnetic polarity. Reversed polarity was found only from two sites: one at the uppermost horizon of the Honda Group, and the other in the Gigante Formation. Plot of the VGP latitudes vs. the stratigraphic section (Fig. 5) shows that the normally magnetized sites compose a thick normal magnetozone covering the middle to upper part of the Honda Group.

It is difficult to clarify the correlation between the Honda Group and a geomagnetic polarity time scale based on the present magnetostratigraphic result. This is partly due to a lack of age control for the Honda Group and partly due to frequent geomagnetic reversals during the Miocene time. No micropaleontological data is available from the continental deposits

Table 1. Paleomagnetic results from La Venta Badlands.

Site	Locality	Dm	Im	N	A95	k	P	PHI	LMD
121	NV3	-164.2	-3.9	3	14.4	74.7	R	-74.2	-3.9
115	NV5	11.4	4.9	3	9.4	171.8	N	78.6	18.6
103	LV13	-167.5	-13.9	3	22.4	31.2	R	-77.0	-182.6
104	LV13	-53.7	42.5	3	22.1	32.3	I	34.1	-137.6
105	LV13	-3.4	13.8	3	7.4	276.3	N	85.0	-117.6
106	LV13	27.5	4.8	2	49.8	27.3	N	62.5	15.8
107	LV13	-23.9	-9.8	2	50.6	26.9	N	64.7	-184.2
108	LV13	-10.5	-3.1	3	39.3	10.9	N	78.4	-190.0
111	LV9	-11.9	-1.2	3	10.6	136.1	N	77.5	-183.2
112	LV9	-7.4	6.2	3	17.2	52.2	N	82.6	193.4
113	LV9	6.4	2.2	3	13.4	85.2	N	83.2	33.5
114	LV8	0.5	-6.9	3	21.6	33.6	N	83.2	-259.5
118	ED3	12.7	0.0	3	40.4	10.4	N	76.9	29.8
119	ED3	-11.1	0.7	3	9.6	167.4	N	78.5	180.0
120	ED3	-13.2	-4.6	3	10.0	153.9	N	75.7	-188.1
117	ED1	13.9	-5.0	3	12.5	98.6	N	74.9	-322.8
116	ED1	8.1	-20.4	3	9.1	185.4	N	74.0	-285.4

Dm and Im: mean declination and inclination in degree

N: number of specimens

A95: radius of 95% confidence circle

k: precision parameter (Fisher, 1953)

P: polarity (N: normal, R: reversed, I: intermediate)

PHI and LMD: latitude and longitude of VGP position in degree

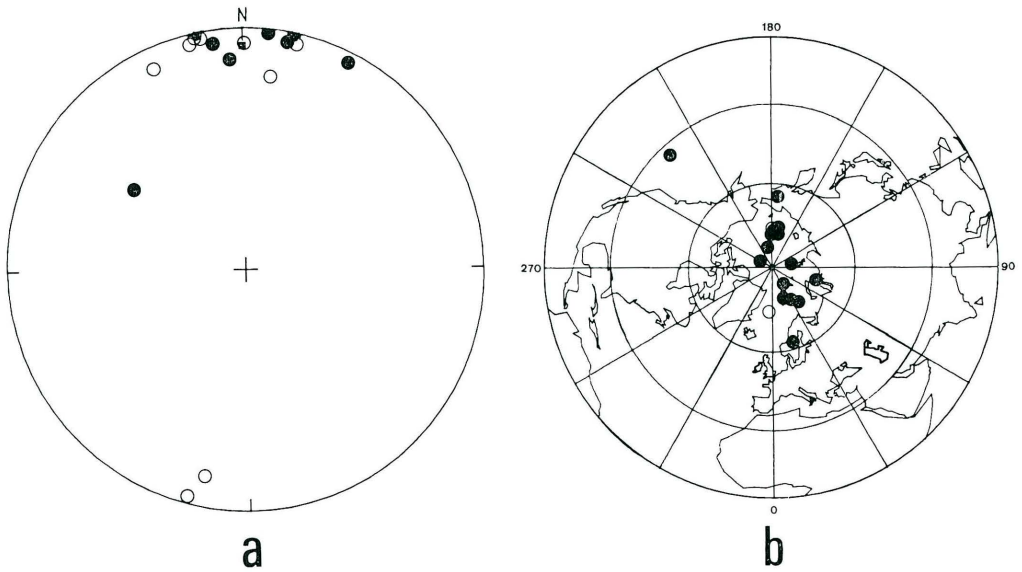


Fig. 4 Equal-area plot of site mean directions (a) and VGP positions (b). The square shows the geocentric axial dipole field direction. Solid symbols are on the lower (northern) hemisphere, and open symbols on the upper (southern) hemisphere.

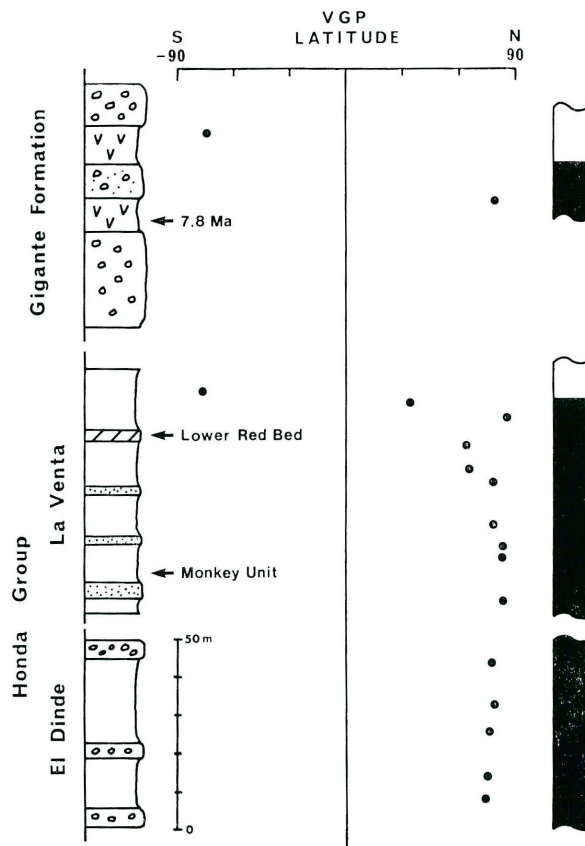


Fig. 5 Plot of VGP latitudes vs. stratigraphic horizons. The fission track age of the Gigante Formation (Takemura and Danhara, 1983) is also shown.

in and around the surveyed area, and no radiometric age has been obtained from the Honda Group.

In the course of the present study, samples for fission track dating were collected from bentonite beds intercalated in the Villa Vieja red beds of the uppermost Honda Group. Van Houten (1976) suggested that the Villa Vieja red beds are volcanoclastic deposits produced by explosive volcanism. Unfortunately, zircon crystals extracted from the bentonite samples had scuffed surfaces, which are characteristics of reworked material. Consequently, fission track dating on these samples were abandoned.

As mentioned before, the La Venta fauna was assigned to the Friasian Stage, which is dated at about 14 to 15 Ma (Hirschfeld and Marshall, 1976; Marshall et al., 1977). If the correlation of the vertebrate fauna is chronologically correct, the Honda Group in La Venta Badlands is suggested the Middle Miocene in age. Then, the normal polarity zone found in the Honda Group is probably correlated to a part of Epoch 15, the normal polarity interval dated from 15.2 to 13.6 Ma (Lowrie and Alvarez, 1981).

The other possibility is that the long normal magnetozone of the Honda Group may be assigned to Epoch 9 (Anomaly 5). This correlation is supported by the fact that Epoch 9 has a particularly long duration expanding from 10.3 to 8.8 Ma (Lowrie and Alvarez, 1981). Other normal polarity intervals in the Miocene including Epoch 15 are estimated to span less than 0.5 m.y., divided by relatively long intervals of reversed polarity. The correlation of the Honda Group to late Miocene Epoch 9 does not conflict with the radiometric ages of the overlying Gigante Formation, about 8 Ma (Van Houten, 1977; Takemura and Danhara, 1983).

It should be noted that the correlations mentioned above are just tentative possibilities. Further paleomagnetic sampling is necessary to clarify assignment of the normal polarity zone in the Honda Group and to estimate absolute age of the La Venta fauna.

The paleomagnetic results give information on tectonic motion of Colombian Andes since the Miocene. The VGP's determined from the Honda Group and the Gigante Formation are well clustered around the present geographic poles, except for one intermediate site (Fig. 4). Thus, it is evident that the sampling area was subjected to neither rotational motion nor north-south translation of significant amount after the time of deposition. On the other hand, MacDonald (1980) revealed that the late Miocene intrusive rocks in the Cauco depression, west of the central Cordillera of Colombian Andes, provide deflected paleomagnetic directions of northwest trend. This anomalous magnetic trend was attributed to large and rapid tectonic re-orientation of the Cauco basin, probably caused by young Andean movement. The present results suggest that the two basins, the La Venta and Cauco, in the east and west of the Central Cordillera suffered different history as separate tectonic blocks after the late Miocene.

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